# CO2 leakage up from a geological storage site to shallow fresh groundwater: CO2-water-rock interaction assessment and development of sensitive monitoring

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# $CO_2$ leakage up from a geological storage site to shallow fresh groundwater: $CO_2$-water-rock interaction assessment and development of sensitive monitoring

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The assessment of environmental impacts of carbon dioxide storage in geological repository requires the investigation of the potential $CO_2$ leakage back into fresh groundwater, particularly with respect to protected groundwater reserves. We are starting a new project whith the aims of developing sensitive monitoring techniques in order to detect potential $CO_2$ leaks and their magnitude as well as their geochemical impacts on the groundwater. In a predictive approach goal, a modelling study of the geochemical impact on fresh groundwaters of a $CO_2$ intrusion during geological storage was performed and serves as a basis for the development of sensitive monitoring techniques (e.g. isotope tracing). Then, isotopic monitoring opportunities will be explored.

A modeling study of the geochemical impact on fresh groundwaters of the ingress of $CO_2$ during geological storage was conducted. The 3D model includes (i) storage saline aquifer, (ii) impacted overlying aquifer containing freshwater and (iii) a leakage path way up through an abandoned well represented as 1D porous medium and corresponding to the cement-rock formation interface. This model was used to simulate the supercritical $CO_2$ migration path and the interaction between the fluid and the host rock.

The model uses the carbonate saline Dogger aquifer in the Paris Basin as the storage reservoir and the Albian formation (located above the Dogger) as the fresh groundwater aquifer. The principal geochemical process simulated is the acidification of groundwaters due to $CO_2$ dissolution, inducing the dissolution of minerals in the Albian formation. Knowing the mineralogical composition of the impacted aquifer is therefore crucial if we are to correctly determine which elements might be release during the arrival of $CO_2$ in freshwater. Estimates of increases in element concentrations are proposed along with a direct control of the injection procedure. This predictive modeling approach impact of $CO_2$ intrusion to fresh groundwaters, illustrates the importance of understanding the interplay between flow and geochemical interaction.

Another way of consideration is isotope systems that seem to be alternative and persuasive tools to record geochemical modifications induced by $CO_2$ intrusion to predictive model. Moreover, knowledge of fluid chemical and isotope compositions are essential to assess

$CO_2$-water-rock interaction. Witihin the iusotopic approach, laboratory experimentations using Albian representative rock samples will be developed in order to display these tracking tools. The main focus is to point out suitable isotope systems which can characterize water rock interactions, redox conditions evolution, $CO_2$ movement, etc. Under very precise protocol, the strontium and carbon isotopes for instance are used to study the effect of carbonate dissolution through its impact on the $CO_2$ concentration. Such isotope systems require the application of different types of methods and apparatus. IRMS (Isotope Ratio Mass Spectrometer), CF-IRMS (Continuous flux- Isotope Ratio Mass Spectrometer), TIMS (Thermo-Ionisation Mass Spectrometer) and the new generation isotope ratio mass spectrometers MC-ICP-MS that will be used for a large set of isotope systems. Thus, isotopic fractionation will be investigated in the frame of this work in the next future: fractionation is interesting since it is mechanism-dependent, e.g. isotopic exchange reactions, physical and chemical processes as kinetic aspect or state changes. These instrumental advances open news research field and favour the use of multi-isotope approaches in isotopic studies as the main interest of hazardous trace elements transport and geochemical evolution of groundwater due to $CO_2$ intrusion.